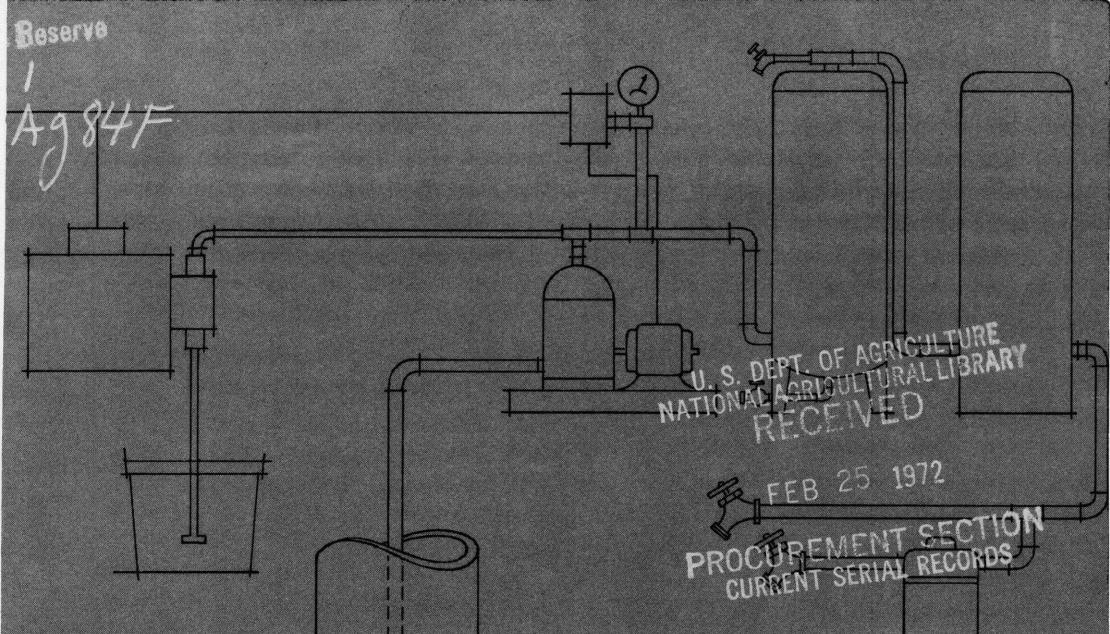


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TREATING FARMSTEAD and RURAL HOME WATER SYSTEMS

• FARMERS' BULLETIN No. 2248
U. S. DEPARTMENT of AGRICULTURE

2491 Treating Farmstead and Rural Home Water Systems //

Information for this publication furnished by the Agricultural Engineering Research Division, Agricultural Research Service

Water as obtained from natural sources may be contaminated with disease-producing organisms, making it unsafe to drink. Or, it may contain large amounts of minerals, making it too "hard" for good laundering, bathing, or cooking. Or, it may have a bad taste or odor—not necessarily a health hazard, but objectionable.

Water from ponds, streams, and other surface sources is almost always contaminated. Water from wells and springs—commonly called ground water—is less likely to be contaminated, but may contain more dissolved minerals or gases.

A good source of supply should yield water of uniform quality. Any noticeable change in the quality should be regarded with suspicion. Contamination should be suspected with any change in color, turbidity, or taste; and the water should be tested to ascertain its safety.

WELL CONSTRUCTION

Water-quality improvement begins at the source. Wells are the most common—and the recommended—source of water for farmstead and rural-home water systems.

The importance of proper well construction cannot be overemphasized. Faulty construction is the chief cause of contaminated wells.

Deep ground water—the preferred source of water for wells—is rarely contaminated. Contamination occurs because contaminated surface water gets into the well. There is much less chance of this happening if the well is properly cased, grouted, and sealed.

If your well water becomes contaminated, you should make every effort to find and eliminate the cause. Treatment of the water to disinfect it should be done only as a last resort.

Well construction is discussed in Farmers' Bulletin 2237, "Water Supply Sources for the Farmstead and Rural Home". For a free copy, send a post card to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250. Include your ZIP Code in your return address.

WATER TESTING

Water from all sources is subject to contamination. Therefore, water from any source should be tested for sanitary quality, or purity, before it is first used and regularly thereafter. Tests for chemical and physical quality may also be desirable. Experience with other wells in the area will provide clues for this need.

Your State or local health office

can tell you where you can have your water tested. Some States maintain water-testing laboratories; private laboratories are available in most States. Fees may be charged.

The usual procedure is to send a water sample to the laboratory through your local health office. The laboratory returns a report. Treatment of the water is based on the report.

Bacteriological Test

A bacteriological test tells you if your water is safe to drink.

The laboratory checks for coliform bacteria, a type found in the intestinal tracts of humans and warm-blooded animals.

The presence of fecal coliform in the water sample indicates that bird, animal, or human excreta is getting into the water. While the excreta may not necessarily contain disease germs, the water must be considered unsafe to drink because a path of entry for such germs exists.

A "coliform negative" report means that the water sample shows no evidence of bacterial contamination. There is no assurance, however, that the water supply may not become contaminated at some future time. Therefore, periodic testing is essential.

Chemical Test

A chemical or mineral analysis indicates the extent of impurities in the water. Large amounts of minerals and other impurities are objectionable because they affect the use characteristics and appearance of water.

Public Use of Your Water System

If your water system will be used by the public—for example, in a campground or a recreation area—it may have to meet certain standards. Consult your local health officer.

Calcium and magnesium, for example, make water hard. Hard water is less desirable for bathing, laundering, and cooking than soft water. It requires more soap to form suds. When heated, it leaves a scale in pipes and heaters.

Iron in water contributes to water hardness. It may also leave red stains on plumbing fixtures, equipment, and laundry.

Suspended silt makes water look muddy or cloudy. Dissolved gases and organic matter may give it a bad taste or odor.

Common water-quality problems, their signs, and the causes are given in the accompanying chart.

Taking A Water Sample

Special care is required when taking a water sample. Contact the laboratory that will test the water both for instructions and for a bottle in which to collect the sample. In some cases, the laboratory may prefer to take the sample.

In the absence of specific instructions, follow this procedure:

1. Obtain a sterile bottle from the testing laboratory. *Let nothing except the water that is to be tested come in contact with the inside of the bottle and cap.*
2. Inspect the outside of the

faucet for leaks around the handle. If there is leaking, select another faucet from which to take the sample.

3. Clean and dry the outside of the faucet.

4. Allow the water to run full force for at least a minute before you collect the sample.

5. Collect the sample, holding the bottle so that any water that comes in contact with your hand cannot run into the bottle. Cap the sample immediately.

6. Deliver the sample to the laboratory as soon as possible. A sample more than 24 hours old may not give accurate results.

Common Water Quality Problems, Signs, and Causes

Problem	Common signs	Causes
"Hard" water-----	Large amount of soap required to form suds. Insoluble soap curd on dishes and fabrics. Hard scaly deposit in pipes and water heaters.	Calcium, magnesium, manganese, and iron (may be in the form of bicarbonates, sulfates, or chlorides).
"Red" water-----	Red stains on clothing and porcelain plumbing fixtures. Metallic taste to water. Red slime in toilet tank. Faucet water turns rust colored after exposure to air.	Iron or manganese, or iron bacteria.
"Rotten egg" odor and taste.	Iron, steel, or copper parts of pumps, pipes, and fixtures corroded. Fine black particles in water (commonly called black water). Silverware turns black.	Hydrogen sulfide gas, sulfate reducing bacteria, or sulfur bacteria.
Off taste (other than "rotten egg").	Water tastes bitter, brackish, oily, or salty, or has a chlorine odor or taste.	Extremely high mineral content. Organic matter present. Excessive combine-chlorine residual. Water passing through areas containing salty or oily waste.
"Acid" water-----	Metal parts on pump, piping, tank, and fixtures corroded. Red stains from corrosion of galvanized pipe; bluegreen stains from corrosion of copper or brass.	Carbon dioxide. In rare instances, mineral acid—sulfuric, nitric, or hydrochloric.
Turbidity-----	Dirty or muddy appearance-----	Silt, sediment, small organisms, or organic matter.

Note: Precautions should be taken to preserve the volatile compounds in the water sample. Carbon dioxide and hydrogen sulfide are lost from water on exposure to the air. As discussed later in the bulletin (page 13), the pH (acidity-alkalinity value), or the free CO₂ concentration, or both, are important in selecting the method to use for acid neutralization and iron removal. For this reason, on-site testing of the water is suggested if possible.

WATER TREATMENT

Treatment to improve the sanitary, or bacteriological, quality of water is known as disinfection. Chlorination is the method most commonly used for small, private water systems and the one usually recommended by public health authorities. There are other methods of disinfecting water, but for various reasons they are less practical than chlorination.

Treatment to improve the chemical and physical quality of water

CAUTION

None of the methods of disinfecting water is 100 percent reliable. Each has limitations and disadvantages. As the only treatment, chlorination or the other methods are satisfactory only for the treatment of clean, clear water from a well-protected source.

Disinfection of polluted water, such as from ponds, lakes, and other surface water sources, generally requires additional treatment, such as sedimentation, coagulation, and filtration.

is known as conditioning. It may include softening, removal of iron or manganese or both, neutralization of acidity, removal of sulfur (hydrogen sulfide), and the control of turbidity.

Chlorination

Chlorine is a good disinfectant and oxidizing agent. In sufficient concentration in water, and with adequate contact (exposure) time, it will kill coliform bacteria and disease organisms, reduce the bad tastes and odors of decaying vegetation, and oxidize sulfur, iron, and other impurities.

In chlorinating your water, you need to add enough chlorine to produce a certain amount of free-chlorine residual in the water. Before specific chlorinating instructions are given, the action of chlorine in water should be reviewed to show why a free-chlorine residual is so important.

Action of chlorine in water

Figure 1 depicts the action of chlorine in water as the dosage, or the amount of chlorine added, is increased.¹

When added to water, chlorine first reacts with any hydrogen sulfide, manganese, iron, and nitrites in the water. The amount of chlorine that reacts with these reducing agents is called the initial chlorine demand. This chlorine does no

¹ The graph depicts the action of chlorine in a specific water sample. Some variation in the graph might be expected with other water samples, depending on the amount of impurities in the water and other factors.

Ordinary laundry bleach—sold in grocery stores under various trade names—is commonly used for disinfecting small water systems. It is normally 5.25-percent sodium hypochlorite, or 2.5-percent active chlorine, or 50,000 p.p.m. (parts per million) available chlorine. One gallon of the bleach is enough to give 5,000 gallons of water a chlorine dosage of 10 p.p.m.

Stronger chlorine compounds, containing up to 70 percent available chlorine, can be bought to disinfect larger water systems. These include calcium hypochlorite in tablet or powder form.

Four types of chlorinators are available — positive displacement, suction, aspirator, and tablet. They differ in operation, reliability, and cost. All such factors should be considered in making a selection.

- *Positive displacement.*—One kind of positive-displacement chlorinator consists of a simple, electric, diaphragm-type pump. With each discharge stroke, it injects a fixed volume of chlorine solution into the water. This kind is not suitable for use where the pumping rate fluctuates widely.

The second kind of positive-displacement unit is actuated by the flow of water through it (it has a mechanism similar to a water meter). It injects the chlorine solution into the water in proportion to the rate of water flow. Thus, it will maintain a more uniform dosage where there is a wide variation in the pumping rate than the first kind.

- *Suction.*—One kind of suction chlorinator consists of a chlorine control unit and a single line run-

ning from the chlorine container through the control unit to the suction side of the pump. The suction developed by the pump draws the chlorine solution into the water supply. Pump suction is rarely stable enough to insure a uniform dosage.

The second kind of suction unit is similar in design, except that the discharge line terminates down in the well next to the foot valve or the intake of the submersible pump. The chlorine solution flows directly into the well water and is drawn into the pump suction along with the well water. This provides a slight increase in contact time and disinfects the riser pipe and pump.

- *Aspirator.*—This is a simple, inexpensive unit, which has no moving parts and does not require electricity for operation. It works on a simple hydraulic principle: Water flows through a venturi tube, creating a suction which draws the chlorine solution into the water supply. This type—and all other suction types—have small orifices that are subject to blocking. Precise dosage adjustment may be difficult.

- *Tablet.*—This type consists of a container of hypochlorite tablets or a granular compound. Some water from the water supply bypasses through the container, forms a chlorine solution, and then flows back into the water supply. This unit does not require electricity for operation and can operate where the water pressure is low. Dosage is affected by both the water flow rate and the water pressure.

Figure 2 shows a recommended chlorinator installation to inject the chlorine solution between the pump

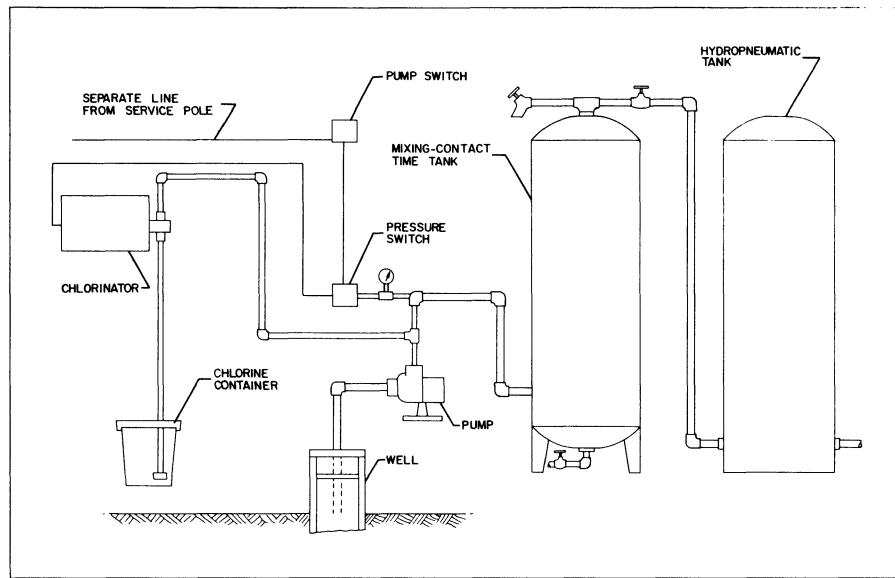


Figure 2.—Recommended installation of a chlorination system for disinfecting water from a well.

and tank (mixing tank or pressure tank or both). This is the usual method when the water source is a well. The solution should be injected as far ahead of the tank or tanks as practical to increase the contact time.

Contact time

Chlorine requires time to completely disinfect water. You must allow adequate "contact time" between the time of chlorine injection and water use. And, at the end of the contact time, there must be an adequate detectable free-chlorine residual in the water to show that disinfection is complete.

The length of contact time required can vary depending on the strength of the free-chlorine residual and the temperature and pH of the water. The stronger the residual, or the higher the water temperature, or the lower the pH, the less contact

time required. At least 5 minutes contact time is recommended.

Water velocity is usually about 6 feet per second (360 feet per minute) in farmstead and rural-home water systems. At that rate of flow, most systems will require some special means of mixing and holding the water long enough to provide adequate contact time.

Use of a mixing tank (fig. 3) is the recommended method of providing additional contact time. The tank should have a theoretical water-detention time of 10 to 15 minutes. To determine the minimum size needed, multiply the capacity of your pump by 10. For example, if the capacity of your pump is 5 gallons per minute, you will need a 50-gallon tank.

The mixing tank is in addition to the pressure tank used in most water systems. Use of a large pressure

tank, or more than one pressure tank, is not a dependable method of providing additional contact time. The reason for this is that when water is being pumped and drawn at the same time, the fresh water may bypass the water already in the tank.

Some installations provide additional contact time by allowing the water to flow through a long length of coiled plastic or copper pipe. (About 600 feet of 1½-inch pipe would be required to provide 5 minutes contact time in an 8-gallon-per-minute water system.) However, this method is less desirable than the mixing tank for two reasons: First, as scaling and sedimentation occur in the pipe, contact time will be reduced; second, the additional pipe length would result in additional friction loss.

Operating chlorinators

Follow the chlorinator manufacturer's directions for mixing the chlorine solution and adjusting the unit to deliver the dosage required to obtain the desired free-chlorine residual.

Chlorine solutions gradually lose their strength when standing. Fresh solutions must be prepared as necessary to maintain the desired residual.

Add enough chlorine to your water to produce a minimum of 0.5 to 1.0 p.p.m. free-chlorine residual after 5 minutes contact time. Water so chlorinated would be considered safe to drink.

Use the test kit supplied with the chlorinator to measure the amount of free-chlorine residual in the

water. Two types of kits are in common usage—orthotolidine and Palin DPD. Follow the instructions in the kit carefully—with some kits you can measure both combined-chlorine residual and free-chlorine residual. The Palin DPD method is more precise for measuring free chlorine than the orthotolidine.

Keep a close check on the operation and effectiveness of your chlorination system. Keep the test kit near the kitchen sink or in some other handy location, out of the reach of children, and test the free-chlorine residual daily (fig. 4). If necessary, increase the dosage to maintain the desired amount of residual.

Once you increase the chlorine dosage, never decrease it. While subsequent testing may show an increase in the free-chlorine residual because of a decrease in the chlorine demand, assume that there may again be an increase in the chlorine demand. If you decrease the dosage, your water may not be completely disinfected if and when the demand does increase.

It may be necessary to maintain a high concentration of free-chlorine residual in your water much of the time to have adequate protection during periods of high chlorine demand. This can give the water an objectionable chlorine taste and odor. The residual can be removed by an activated carbon dechlorination filter at the point of use.

If the free-chlorine residual varies greatly in short periods of time, contamination entering the well above the water table should be suspected. Every effort should

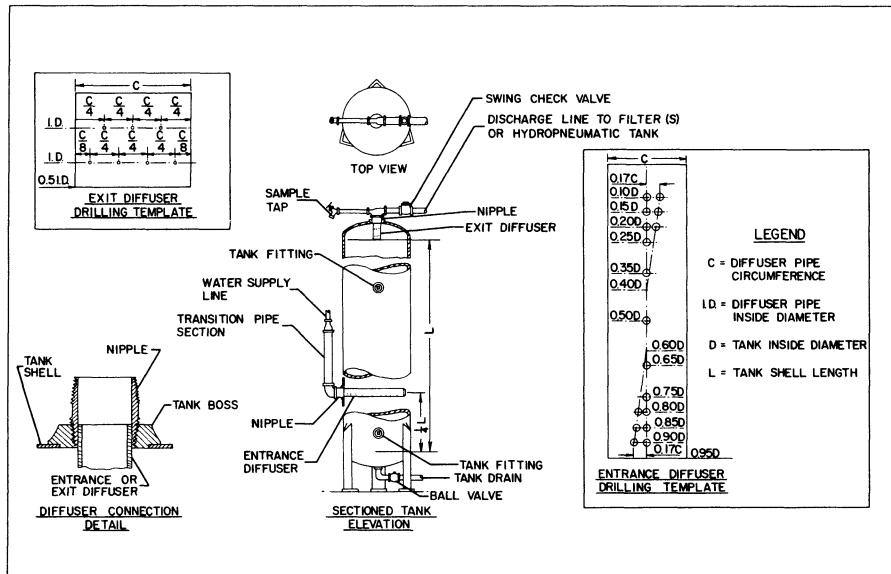


Figure 3.—Mixing tank to provide additional chlorine "contact time" for complete disinfection. A low water-entrance velocity of 1 foot per second and a high exit velocity of 6 feet per second are required for a proper flow pattern and to minimize short circuiting (water entering the tank from bypassing that already in the tank).

Specifications:

Tank: Volume should be 10 to 15 times the water system flow rate in gallons per minute.

Pipe sized for flow rate velocity of 4 feet per second: Water supply line, tank drain line, and discharge line.

Pipe sized for flow rate velocity of 1 foot per second: Transition section, entrance diffuser, and exit diffuser.

Entrance diffuser: 17 holes—11 on bottom, 3 on each side (to induce radial flow). Hole diameter is 0.25 of inside diameter of pipe. See template drawing in illustration.

Exit diffuser: 9 holes—8 on side, 1 in bottom center. Hole diameter is 0.14 of inside diameter of pipe. See template drawing in illustration.

Nipples: Short or longer. One size larger than transition section and entrance and exit diffusers. Use Schedule 40 or 80 as required for best fit.

Tank fittings: Install extra fittings as desired.

Cleaning:

To flush sediment from tank: Turn off pump and open sample tap and tank drain valve. When tank is empty, turn pump on and run water to waste until clear. Close drain valve, but leave tap open. Fill tank, bleeding air to waste through tap until tank is full.

be made to locate and eliminate the source of the contamination.

Keep a dated record of your solution preparations and free-chlorine-residual test results for reference and comparison purposes.

"Batch" disinfection

The best way to disinfect, or chlorinate, water having wide variations in the chlorine demand is by the "batch" method. In some cases, this might even be the most econom-

ical way. This method insures that all water is adequately disinfected before use.

The "batch" method calls for the use of three equal-size tanks, each large enough to hold a 2 or 3 days' supply of water. While one tank is being used, another is being treated, and the third is being filled. A typical cycling would be :

Tank No.	Cycle phase 1	Cycle phase 2	Cycle phase 3
1	Fill	Treat	Use
2	Treat	Use	Fill
3	Use	Fill	Treat

These tanks are also useful in treatment procedures for hardness, iron, and dissolved gases.

Other Water-Disinfection Methods

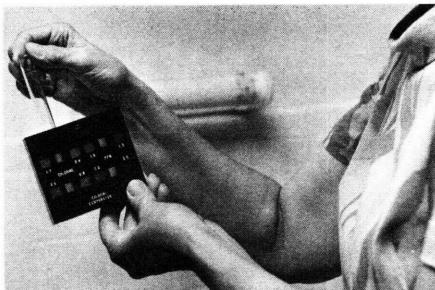
Methods of disinfecting water besides chlorination include: Boiling, pasteurization, ultra-violet light, and ozone disinfection. Compared with chlorination, these methods are either less practical, too expensive, or have some other serious limitation.

Boiling

When bacterial contamination is known or suspected, boiling the water is a good emergency means of sterilizing it. Boil the water vigorously for at least 2 minutes to assure safe water.

Note: Sterilization kills all organisms. Disinfection reduces the concentration of organisms to safe levels.

The cooled water must be protected from recontamination. The objectionable flat taste can be reduced by aeration.



PN-2420

Figure 4.—To be sure that your drinking water is safe at all times, test the free-chlorine residual regularly—everyday is recommended. This housewife is using the color-comparison test kit supplied with her chlorinator.

Pasteurization

Pasteurization is a heat method of disinfection. "Flash" pasteurization—the method of pasteurizing milk—calls for a high temperature (160° F.) for only a short exposure period (15 seconds). It is not practical for most waters. "Low temperature" pasteurization calls for heating the water to a temperature of 140° to 145° F. for at least 10 minutes.

Heating water is expensive and the efficiency of the heat exchangers in the pasteurizing units is limited. Also, the increased temperature of the water may reduce its palatability and increase the heat stress on livestock if they drink less.

Ultraviolet light

Certain ultraviolet wavelengths have a high germicidal effect. However, color, turbidity, and organic impurities in water interfere with the transmission of the ultraviolet energy and may reduce the disinfection efficiency to unsafe levels.

Also, as the common bacterial indicator organisms—that is, coliform

and fecal coliform bacteria—are killed at lower UV exposures than some disease organisms, expensive bacteriological tests are required to assure adequate performance.

Ozonation

Disinfection by ozonation is not considered practical for farmstead and rural home water systems. Ozone is a much more powerful disinfectant than chlorine, but, because of its extreme chemical activity, ozone concentrations greater than normally in the atmosphere are regarded as potentially harmful. The ozone concentration in the disinfected water must be reduced to zero. In large water systems, this is accomplished by normal delays in usage. Lengthy delays in usage usually do not occur in smaller water systems.

Water Softening

Calcium and magnesium (and sometimes iron) in water make it hard. The water dissolves these minerals as it passes through soil and rock formations.

The best way to soften water in smaller water systems is to run it through a water softener unit connected into the water supply line.

Usually, softened water is supplied only to the bathtub, lavatories, kitchen sink, and laundry. Water for the toilet and for the lawn, garden, and other nonhousehold uses bypasses the softener. This reduces the load on the unit and thus the frequency of recharging.

Water softeners consist of a tank containing an ion-exchange material—zeolite or resin beads. (Some

designs include a second tank which contains a brine solution for regenerating the ion-exchange material.) When the water passes through the zeolite or resin beads, "hard" calcium and magnesium ions are exchanged for "soft" sodium ions and the water is softened.

Water hardness is usually measured in terms of "grains per gallon" of hardness minerals. Water softeners are rated as to the grains-per-gallon hardness they can handle, their grain-exchange capacity before regeneration is needed, and the pump capacity or water service flow rate required. For example, a softener rated at 20,000 grains of hardness exchange capacity will soften 1,000 gallons of water containing 20 grains per gallon before regeneration is needed.

Water softeners should be regenerated before their water-softening capacity is exhausted. This is done by—

1. Backwashing, or reversing the flow of water through the softener, to flush out accumulated sediment and oxidized iron.

2. Adding a strong salt brine to regenerate the exchange material. The sodium ions in the salt replace the "hard" calcium and magnesium ions in the exchange material.

3. Slowly rinsing away to waste the released calcium and magnesium ions.

Water softeners are designed for automatic, semiautomatic, or manual regeneration. Fully automatic units regenerate on a predetermined schedule (controlled by a time clock or other device) and return to service automatically. Semiautomatic

units are started manually, but otherwise are automatic. With manual units, all steps in the operation—backwashing, brining, and rinsing—are manually controlled.

Some waters will clog the softener, necessitating backwashing before regeneration is needed. In these cases, manual controls are desired.

In many areas, there are companies that provide a water softening service. For a monthly fee, the company installs a softener unit and replaces it periodically with a freshly charged one.

Iron Removal

Many water supplies will contain some iron. The iron may be picked up or dissolved by the water as it passes through underground iron deposits or from contact with the metal parts of the water system—the well casing, pump, and piping. The more corrosive the water the more iron it will dissolve from contact with the metal parts.

Iron in the ferric form will stain clothes and plumbing fixtures. Ferric iron occurs when ferrous iron in well water is exposed to the air.

Iron is not considered a health problem, but it can be very objectionable if present in amounts greater than 0.3 p.p.m. The U.S. Public Health Service recommends that drinking water contain not more than 0.3 p.p.m. of iron.

Iron bacteria are nuisance organisms often associated with soluble iron in water. They can be quite objectionable with iron concentrations as low as 0.1 p.p.m. ferrous (soluble) iron. Calcium is an essential nutrient for the bacteria.

The presence of the bacteria is indicated by a gelatinous slime on the inside wall of the toilet flush tank and gelatinous "rusty slugs" being discharged at the tap. Dirty plumbing tools may spread them.

High dosages (200 to 500 p.p.m.) of chlorine (known as shock chlorination or disinfection) are required to eliminate iron bacteria.

Four types of iron-removal equipment are available:

- *Water softeners.*—Some water softeners contain a zeolite mineral that will remove soluble iron on an ion-exchange basis (the same way as calcium and magnesium are removed in water softening). Depending on the kind of zeolite used, up to 10 p.p.m. of soluble iron can be removed. The slime produced by iron bacteria will clog the zeolite and reduce its effectiveness.

- *Polyphosphate feeders.*—These units can handle up to 3 p.p.m. of iron in solution. They contain a phosphate compound which "coats" the soluble iron and prevents its oxidation when the water is exposed to air. The compound is not effective against iron that has already oxidized. In some waters, the results may be unsatisfactory for hot water.

- *Iron-removal filters.*—These units will remove up to about 10 p.p.m. of iron. They look much like water softeners, except that they contain a bed of natural or synthetic manganese green sand. Manganese dioxide furnishes oxygen to oxidize the iron, and most of the iron-oxide particles are filtered out in the lower half of the bed.

The filter bed must be backwashed

frequently to remove the accumulation of iron particles. For back-washing, a flow rate more than double the normal service flow rate is usually required.

Acid waters below a pH of 6.8 will pick up manganese from the green-sand surface and cause loss of oxygen-exchange capacity. The slime produced by iron bacteria will clog the filter.

When the manganese is exhausted, it is regenerated with potassium permanganate.

• *Chlorinator and filter.*—Chlorination followed by filtration through a sand or carbon filter can remove any quantity of iron in any form. The chlorine oxidizes and precipitates the iron and the filter strains out the particles.

This method also destroys iron bacteria. When the bacteria cannot be permanently eliminated by shock chlorination, continuous chlorination is required.

Neutralizing Acid Water

Both ground water and surface water may be acidic. In ground water, the cause is usually free carbon dioxide in the water. The gas may come from decaying organic matter or it may be brought down from the air by rainwater.

In some cases, particularly in mining areas, water may contain free mineral acid—hydrochloric, sulfuric, or nitric.

Acid water corrodes the metal parts of water systems—the pump, piping, water tank, water heater, and fixtures. Depending on the kind of metal attacked—copper or galvanized—it causes blue or green

stains or red stains on fixtures and clothes.

Acid water also prevents the complete oxidation of iron in water. The acidity must be neutralized for effective removal of iron.

The acidity and alkalinity of water are measured on a pH scale of 0 to 14. Water having a pH of 7 is neutral. Below 7, the water is acidic; above 7, it is alkaline.

Natural waters are complex solutions of many substances. Deep well water having a pH near or above 7 can have a high CO₂ concentration and be very corrosive. In selecting the method of acid neutralization or corrosion control, it is desirable to know the pH, free CO₂ concentration, hardness, and alkalinity. Use the chart on page 15 as a guide.

Objectionable Tastes and Odors

Your water may have a bad flavor or a bad odor or both. It may taste or smell oily, metallic, salty, fishy, or like a rotten egg. While not usually a health hazard, the bad taste or odor can make the water undesirable for cooking and drinking.

Possible causes of bad tastes or odors in water include dissolved minerals or gases, decaying organic matter, microscopic plant or animal organisms, and industrial waste.

A rotten egg taste or odor indicates the presence of hydrogen sulfide in the water. Besides having a bad taste and odor, water containing this gas (called sulfur water) corrodes iron and other metals in the water system and stains the fixtures. Correction is needed if there is more than 1 p.p.m. of sulfur in the water.

Guide for Selecting Method of Neutralizing Acidity and Controlling Corrosion in Water

Method	Suggested pH or free CO ₂ concentration	Results	Remarks
Aeration-----	Below 5.5 pH; over 200 p.p.m. CO ₂ .	Releases CO ₂ to atmosphere; oxidizes iron.	Normally requires at- mospheric exposure and second pump (intermediate water storage).
Caustic soda feed.	Below 5.5 pH; over 75 p.p.m. CO ₂ .	Forms one-half the sodium bi- carbonate of soda ash.	Forms ferrous hydroxide a coagulant from ferrous bicarbonate which aids in precipi- tating iron oxidized by chlorine to reduce filter load.
Soda ash feed...	Over 5.5 pH; less than 75 p.p.m. CO ₂ .	Forms sodium bicarbonate.	No increase in hardness.
Calcium car- bonate filter (marble chip).	Over 6.5 pH; less than 25 p.p.m. CO ₂ .	Forms calcium bicarbonate.	Increases hardness and alkalinity. Subject to iron fouling by ex- change of iron for calcium. Requires high backwash rate.

Hydrogen sulfide may be removed from water by chlorination followed by filtration through an iron-removal filter. The chlorine will oxidize the sulfur and the filter will remove the settled-out particles. The chlorine will also kill sulfur bacteria if present.

When only small amounts are involved, an iron-removal filter by itself will remove the sulfur satisfactorily.

A metallic taste is usually eliminated when the iron content of the water is controlled or when the water is softened.

Most other objectionable tastes

and odors, except a salty taste, can be removed by running the water through an activated-charcoal filter, commonly called a taste-and-odor filter.

Algae are a common cause of bad taste and odor in pond water. One sign of their presence is a green scum on the surface of the water. Check with your local health authorities for their recommendations for control of algae.

Turbidity Control

Water from ponds, streams, and other surface water sources may

have a muddy or cloudy appearance. This is known as turbidity. The cause is large quantities of suspended matter in the water—clay, silt, algae, or organic matter.

Turbidity in excess of 5 p.p.m. is usually objectionable for aesthetic reasons. If the amount exceeds 10 p.p.m., the water may not meet your State's public health standards.

Filtration is required for the removal of turbidity for clear water. When filtration is not completely effective, prefiltration treatment is necessary to reduce the amount of turbidity before the water reaches the filter.

A slow sand filter is commonly used for treating pond water. It consists of an 18- to 24-inch bed of fine sand on top of a 6-inch layer of coarse gravel. The water filters through the filter at a rate of about 3 gallons per hour per square foot of filter-bed area—or about 72 gallons per day. The size of filter-bed area needed will depend on your daily water requirements.

The prefiltration treatment consists of a combination coagulation-sedimentation process. A special substance is added to the water. It causes the suspended matter to collect into larger particles and settle to the bottom.

The water may be treated while in the pond if high turbidity develops only occasionally. But if high turbidity is a continuing problem, the water should be treated in a

special settling tank located ahead of the filter in the water system.

For direct treatment of pond water, powdered gypsum should be spread over the surface of the water at the rate of 12 pounds per 7,000 gallons of water. For tank treatment, an aluminum-sulfate solution should be fed into the tank with an alum feeder.

Aeration of Water

Aeration of water can greatly improve its quality. However, since this process is not usually completely effective, it is best used as an additional or supplemental treatment.

Some of the benefits of aerating water are:

- It allows the escape of dissolved gases such as hydrogen sulfide, methane, and carbon dioxide. This eliminates or reduces the bad tastes and odors and the corrosive action associated with such gases.

- It results in oxidation of ferrous iron in the water. This facilitates removal of the iron by precipitation and filtration.

- It increases the oxygen content of oxygen-deficient water—for example, cistern water. This reduces the flat taste of such water.

Water may be aerated by spraying it into the air, allowing it to cascade over steps, passing it through beds of coarse coke or stone, or bubbling air into it.

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